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SEVENTY-SECOND

ANNUAL REPORT

OF THE

DIRECTOR

OF

THE ASTRONOMICAL OBSERVATORY

OF

HARVARD COLLEGE

FOR THE YEAR ENDING SEPTEMBER 30, 1917

BY

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APR 1 5 1918
UNIVERSITY OF

CAMBRIDGE, MASS.
PUBLISHED BY THE UNIVERSITY
1918

THE OBSERVATORY

To the President of the University: —

Sir, — The policy of the Harvard Observatory may be stated to consist in advancing Astronomy in every possible way, independently of local conditions, or personal considerations. This will involve restoring the friendly international relations which proved so valuable a few years ago. As illustrations of coöperation, or "team work," in progress here, may be mentioned the Durchmusterung of Kapteyn's Selected Areas; the coöperation of the Yale, Princeton, and Harvard Observatories in determining the positions of the Moon by photography; the aid of the Association of Variable Star Observers in observing variables when bright, and when faint, that of Professor Mitchell and Professor Wilson; the courtesy of Dr. Shapley in furnishing photographs of Messier 15 with the 60-inch Mount Wilson Telescope; Professor Plaskett's offer to supply photographs with the 72-inch Telescope for measuring the brightness of very faint stars. To all of the astronomers who have thus coöperated with us our best thanks are due for their liberal and unselfish aid. We have endeavored to reciprocate by furnishing material from our photographs, when desired. The class of spectrum of 23,760 stars has been furnished to astronomers in Denmark, England, France, Germany, Holland, Italy, and the United States.

The principal investigations undertaken here extend over long periods of time, and have accordingly been continued as in previous years. The object is to furnish a large amount of material which may prove useful in studying the laws of the universe. Great care is exercised in securing the highest efficiency in this work. In one investigation, a saving of one minute in the identification of each star effects a saving of two years in the time of one assistant.

Grateful acknowledgment is made of the generous contributions of Mr. George R. Agassiz and Mrs. Charles S. Hinchman, thus materially extending the work of the Observatory.

On the fortieth anniversary of my appointment as Director, the sum of $12,359.13, from one hundred and twenty-two donors from fifteen states, was presented to the Observatory to establish a Fellowship bearing my name. An opportunity is thus provided by which a woman may devote her entire time to astronomical re-

search. My pleasure in the increased aid thus rendered was enhanced by the graceful form of the presentation.

Henry Draper Memorial

Good progress has been made with the Henry Draper Catalogue under the supervision of Miss Cannon. The classification of the spectra is complete, and has been entered on 242,093 cards, relating to about 223,000 stars. Copy has been written for the printer for zero to eighteen hours, although additional facts are still to be entered on it. The first two hours of right ascension have been sent to the printer, and two and three hours, completing H. A. **91,** are now ready. During the year, 41 spectra have been found to be composite, 8 spectra of variables of short period have been shown to vary, 4 new variables have been discovered, and 2 stars having the hydrogen lines bright. In addition, 21 new variables have been discovered, all but two from the photographic plates.

The photographic observations at Cambridge have continued under the supervision of Professor King. The number of plates taken with the 24-inch Reflector is 204, making 1,930, in all; with the 16-inch Metcalf Telescope, 2,374, making 13,629, in all; with the 10-inch Metcalf Telescope, 768, making 1,012, in all; with the 1-inch Cooke Anastigmat, 1,261, making 19,220, in all; with the 0.5-inch Voigtländer, 1,134, making 16,274, in all. The total number of plates exposed was 7,761, of which 6,741 were photographs of the stars. Adding to these the plates taken at Arequipa, the total number of plates taken is approximately 262,962, besides 28,846 photographic copies, enlargements, etc. The number of plates taken for determining the position of the Moon was 194, making 835, in all. During the Lunar Eclipse of January 7, 1917, 19 plates were taken. Asteroids of the tenth magnitude, and brighter, are photographed, systematically, with the 10-inch Metcalf Telescope to determine the brightness and variability, if any. Good progress has been made in taking out-of-focus photographs of the stars and other luminous objects, with yellow light. Interesting results are obtained by enlarging stellar spectra and photographing them through a photographic wedge. The intensity of rays of different wave lengths is thus shown.

Boyden Department

The Arequipa Station continued under the charge of Mr. F. E. Hinkley until May 1, 1917, since then Mr. L. C. Blanchard has occupied this position. As he was alone, the amount of work ac-

complished is remarkable, especially as through a misunderstanding the supply of plates was exhausted for several weeks. The number of plates taken with the 24-inch Bruce Telescope is 146, making 11,722, in all; with the 13-inch Boyden, 23, making 13,106, in all; with the 8-inch Bache, 3,075, making 51,637, in all; with the 1-inch Cooke Anastigmat, 1,089, making 13,629, in all. The total number of photographs of the stars is 5,077. The instruments have been kept in good condition without outside assistance. The residence is receiving much needed repairs. The other buildings and grounds are in good condition except that the former require some painting.

The Mandeville Station in Jamaica has continued under the direction of Professor W. H. Pickering. Some of the more important investigations conducted are the following:—The color of the Sun, stars, and planets by means of a color scale. A selection of the sixty finest objects in the sky. A study of the transparency of our atmosphere, showing that the most southern star readily visible to the naked eye from Mandeville is γ Volantis, magnitude 3.7, declination $-70°.3$, maximum altitude $1°.7$. A study of the shifting white areas on the summit of the central peaks, and on the inner rim of the lunar crater Theophilus. These were attributed severally to snow and clouds. A compilation and study of the results secured at the past opposition by the various members of the "Associated Observers of Mars." Report No. 17 on Mars. An investigation of the Orion nebula, indicating that its distance is a little over 6,000 light years. The measurement of the changing forms of Jupiter's satellites.

Blue Hill Meteorological Observatory

The observational and routine work of the Observatory have been carried on without interruption. Continuous records of the actual and sensible temperature, pressure, humidity, wind direction and velocity, sunshine, night cloudiness, rainfall, snowfall, and evaporation have been obtained. A summary of the data was published in H. A. **83**, Part **1.** In addition to the usual ten tables of mean values and extremes, the volume contains three special articles. These are "The Winds of Boston and Vicinity," Part 2, which is probably the most detailed discussion of the winds of any locality in the United States thus far published. The subject is one of ever increasing value, and the data must be of prime importance in connection with trans-Atlantic aviation. Parts 1 and 2 together make a valuable supplement to the book of Professor

Rotch published in 1911, and which is still the only volume on Charts of the Atmosphere for Aviators and Aeronauts which is available. In Part 1, the duration of the wind from different directions, the different structures, such as prevailing westerlies, sea-breeze, sea-turn, were discussed; also the maximum surface velocities and the relation of winds to precipitation areas. In Part 2, the general circulation, the relative duration of east and west winds, theories of cyclonic origin, and the inadequacy of present theories to support observed facts are given at length.

The second paper in H. A. **83** discusses the need of scientific units in Aerography. Some discussion of the various temperature scales is given with arguments favoring a proposed new absolute scale.

The third paper is on the Ice Saints by Waldo E. Forbes. In this paper Mr. Forbes uses the Rodman records which go back to 1812, and a large number of long range European records. It is the most exhaustive study of these cold periods occurring in Europe about May 10 which has yet been made.

Photographic Magnitudes

The determination of photographic magnitudes on the international scale has continued under the supervision of Miss Leavitt. Series of twelve plates each are ordinarily taken of which the first, seventh, and twelfth are on the Pole, or on the other Harvard Standard Regions. The number of series taken at Cambridge with the 16-inch Metcalf Telescope is 116 with blue light, and 38 with yellow light. The corresponding numbers taken at Arequipa with the 8-inch Bache Telescope are 210 with blue, and 65 with yellow, light. Magnitudes and positions of sequences of stars in each of the fifty Harvard Standard Regions are given in H. A. **71.** Similar sequences of the standard regions of the Carte du Ciel and Kapteyn Selected Areas are nearly completed for the northern stars, and are in progress for the southern regions. Catalogues of the stars in the Harvard Standard Regions are now being prepared. They will give the positions, photographic magnitudes, photovisual magnitudes, and class of spectrum for stars in regions 4° square, of the eleventh magnitude, and brighter. The number of estimates of magnitude made during the year is about 85,000.

Variable Stars

Professor Bailey has continued his work on the variable stars in clusters. The discussion of the variables in ω Centauri, Messier

3, and Messier 5 have already been published. By the courtesy of Dr. Harlow Shapley, an admirable series of photographs of Messier 15, which he had taken with the 60-inch Mount Wilson Telescope, were available, in addition to photographs made during the last twenty years in Cambridge and Arequipa. The results so far obtained in Messier 15 show considerable resemblance to those in ω Centauri and Messier 5, where two or more types of variables were found. In Messier 3, with one exception, only the " cluster type " occurs. In Messier 5, eight stars were found whose mean period was half that of the remaining variables in the cluster. This was explained on the theory of duplicity, which accounts satisfactorily for the length of period and the form of light curve. A somewhat similar condition is found in Messier 15, but in this cluster the number of variables of each type is about equal, and the mean period of one group appears to be somewhat more than half that of the other group.

Numerous observations of variable stars have been made by Mr. Leon Campbell with the 12-inch Polar Telescope and 15-inch Equatorial. With these instruments, he has made 1,526 estimates of variables, mainly when they were too faint to be observed with smaller instruments. He has made 15,240 settings with the polarizing photometers attached to the 15-inch Equatorial, mainly of the planets and asteroids suspected or certainly variable, and of the eclipses of Jupiter's satellites. Eunomia (15) was observed from October to March, 3,920 settings having been secured. The variability of Uranus has been established from 1,792 observations, and that of Antigone (129) has also been confirmed. Iris (7) has been observed through several months. Variations were also found in the planets Neptune and Juno (3), but the nature of their variations had not as yet been determined. During 17 eclipses of the satellites of Jupiter, 1,190 settings were secured.

The Variable Star Section of the British Astronomical Association, under the directorship of Mr. C. L. Brook, has continued its coöperation with this Observatory, having communicated 446 observations of a selected list of stars by seven observers, and furnishing the ten-day means of all the stars observed by them for 1916. The directors of the Goodsell and McCormick Observatories have also maintained an active plan of coöperation, by observing the variables of long period, especially when at or near their minimum phase, 259 observations having been contributed by Professor H. C. Wilson, and 65 by Professor S. A. Mitchell. Professor Mitchell has recently undertaken the determination of the magni-

tudes of the fainter stars of our sequences, which is greatly needed. The American Association of Variable Star Observers, under the supervision of Mr. Olcott, has maintained its active interest in the subject of variable stars and has contributed 15,022 estimates for our use in discussing the numerous light curves. In all, 17,405 observations have been made at, or contributed to, this Observatory during the past year, distributed as follows: —

Mr. T. W. Backhouse, 86; Mr. H. C. Bancroft, Jr., 2,591; Rev. T. C. H. Bouton, 1,025; Mr. F. E. Brasch, 66; Mr. A. B. Burbeck, 964; Mr. F. C. Butterworth, 292; Mr. L. Campbell, 1,526; Mr. J. J. Crane, 249; Mr. F. L. Ducharme, 97; Mr. C. H. Gingrich, 58; Mr. W. P. Hoge, 67; Mr. S. C. Hunter, 269; Mr. G. B. Lacchini, 1,259; Mr. C. B. Lindsley, 77; Mr. W. J. Luyten, 2,826; Mr. C. Y. McAteer, 1,228; Mr. W. P. Meeker, 74; Mr. C. S. Mundt, 360; Mr. G. F. Nolte, 230; Mr. W. T. Olcott, 413; Rev. Ed. de Perrot, 251; Mr. D. B. Pickering, 585; Mr. S. W. Pickering, 116; Mr. W. H. Reardon, 117; Mr. C. F. Richter, 88; Rev. L. Rodés, 57; Mr. F. H. Spinney, 64; Miss H. M. Swartz, 141; Mr. H. Thomson, 66; Mr. H. W. Vrooman, 289; Mr. E. H. Vogelenzang, 420; Mr. C. T. Whitehorn, 507; Professor H. C. Wilson, 186; Professor A. S. Young, 333. Besides these, 363 observations have been communicated by eighteen observers, each of whom has made less than fifty estimates.

The preparation for the printer of the unpublished observations of variable stars for 1911 to 1916 has been practically completed by Mr. Campbell. Messrs. Burbeck, Crane, and Spinney, and Miss Woods have been engaged on the reduction of the observations of special variable stars.

It will be noted that, although fifty-two observers have taken part in the observations here cited, two-thirds of the total number of estimates obtained were made by seven observers.

Miscellaneous

Phillips Library. — The Library of the Observatory has been increased by 137 volumes and 2,300 pamphlets, a marked decrease from previous years. As 2,777 pamphlets have been bound in volumes, the present extent of the Library is 15,072 volumes, and 35,511 pamphlets.

In many cases, my friends have kindly sent a copy of their publications to me as well as to the Observatory. In the case of important works, this second copy is very valuable. After examining them, I deposit them in the Library, where they are available for the other stations we maintain, or where several assistants may

need the same work simultaneously. When the second edition of the Bonn Durchmusterung was issued, we purchased eight copies, several of which by daily use are now badly worn.

Telegraphic Announcements. — Nineteen cablegrams have been sent to Copenhagen, and to astronomers in South America, where communication has not been interrupted. Code messages are not permitted by the censors, and accordingly orbits and ephemerides cannot be sent. It is requested that announcements be sent here, as usual, cablegrams addressed " Observatory, Boston," and telegrams, " Harvard College Observatory, Cambridge, Mass." They will be given as wide a distribution abroad as practicable. Our telegrams are sent at cost to all who wish for them.

Thirty-one Bulletins have been issued, making 645, in all. The restriction in cablegrams gives them an increased value. They are printed promptly and not only contain all the telegraphic announcements, but much additional information sent for that purpose. They are sent without charge to all receiving the telegrams, and at a price less than cost to all others desiring them.

Publications. — During the last year, Volumes **71,** No. **4,** Sequences in Harvard Standard Regions; **78,** Part **2,** Variable Stars in the Cluster Messier 5; **80,** No. **4,** Northern Milky Way; **80,** No. **5,** Systematic Photographic Tests; **80,** No. **6,** Comparison of Stellar Images; **80,** No. **7,** Scale of the Cordoba Durchmusterung, $-52°$ to $-61°$; **80,** No. **8,** The Light Curve of T Andromedae; **80,** No. **9,** Comparison of Color Index and Class of Spectrum; **83,** Part **1,** Blue Hill Meteorological Observatory, 1916; and **84,** No. **2,** Y Camelopardalis and TT Lyrae, have been distributed. **80,** No. **10,** Eclipses of Jupiter's Satellites; **80,** No. **11,** Photographic Positions of the Moon; **84,** No. **3,** Six Circumpolar Variables; and **85,** Durchmusterung of Selected Areas, are partly in type or at the printer's. The set of Annals from **1** to **80** is, therefore, complete and distributed, with the exception of **78,** Part **3, 79,** and **80,** following No. **9. 83,** Part **1,** and **84,** Nos. **1, 2,** and **3,** are also published. Six circulars have been issued, whose numbers, titles, and dates are as follows: —

196. Stars having Peculiar Spectra. 13 New Variable Stars. September 23, 1916.
197. Maxima in 1917 of Variables of Long Period. October 25, 1916.
198. Eclipses of Jupiter's Satellites. November 30, 1916.
199. Asteroids Bright in 1917. January 10, 1917.
200. Variability of Uranus. January 25, 1917.
201. Twenty-one New Variable Stars. July 12, 1917.

EDWARD C. PICKERING, *Director.*

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